Erratum: "H2 Formation on Grain Surfaces" (2004, ApJ, 604, 222)

Cazaux, S.; Tielens, A. G. G. M.

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ERRATUM: "H_2 FORMATION ON GRAIN SURFACES" (2004, ApJ, 604, 222)

S. Cazaux[1] and A. G. G. M. Tielens[2]
[1] Kapteyn Institute, P.O. Box 800, 9700 AV Groningen, The Netherlands
[2] Leiden Observatory, Leiden University, P.O. Box 9513, 2300 RA Leiden, The Netherlands

As noted by Bai & Goodman (2009), the equations for the transmission coefficients to go from a site i to a site j in Cazaux & Tielens (2004) erroneously omitted a key factor and also contained a typo. The correct equations are

$$T_{ij}^{(1)} = 4 \times \sqrt{\frac{E - B_{ij}}{E}} \left[\left(1 + \sqrt{\frac{E - B_{ij}}{E}} \right)^2 + \frac{B_i B_j \left(\sinh \left(\sqrt{\frac{2m(B_i - E)}{\hbar^2}} Z \right) \right)^2}{(B_i - E)E} \right]^{-1} \quad \text{if } E < B_i \,, \tag{1}$$

$$T_{ij}^{(2)} = 4 \times \sqrt{\frac{E - B_{ij}}{E}} \left[\left(1 + \sqrt{\frac{E - B_{ij}}{E}} \right)^2 - \frac{B_i B_j \left(\sin \left(\sqrt{\frac{2m(E - B_i)}{\hbar^2}} Z \right) \right)^2}{(B_i - E)E} \right]^{-1} \quad \text{if } E > B_i \,. \tag{2}$$

These equations differ from Equations (1) and (2) of the original paper in the additional factor $\sqrt{\frac{E-B_{ij}}{E}}$, which is the ratio of the transmitted over the incident wave numbers, with a change of variable in order to define the energy E as being zero at the bottom of the potential well i (e.g., for $T_{\rm pc}$, the energy of the atom is defined from the physisorbed site). The relevant energies B_i, B_j, and B_{ij} are summarized in Table 1 where—compared to the original paper—a small typo in the expression for the B_{ij} has been corrected as well. Note that B_{ij} is negative with these definitions and the omitted factor can greatly increase the values of the transmission coefficient for an H atom to go from a physisorbed site to a chemisorbed site. As a result, the probability for a physisorbed H atom to become chemisorbed increases. By the same token, the H_2 formation efficiency will also increase. Using the parameters for the potential energy curves as described in Figure 15 of Cazaux & Tielens (2004), Figure 1 shows the corrected efficiencies for H_2 formation on olivine and carbonaceous surfaces. For grain temperatures higher than 25 K, these efficiencies are ~3.5 times higher than without the correction. For lower temperatures, where H_2 formation from physisorbed H atoms dominates, the efficiencies remain unchanged.

Table 1
Parameters Used to Calculate the Transmission Coefficients

T_{ij}	B_i	B_j	B_{ij}	Z
T_{PP}	$E_P(k)$–E_{SP}	$E_P(k)$–E_{SP}	0	A
T_{CC}	$E_C(k)$–E_{SC}	$E_C(k)$–E_{SC}	0	A
T_{PC}	$E_P(k)$–E_S	$E_C(k)$–E_S	$E_P(k)$–$E_C(k)$	a
T_{CP}	$E_C(k)$–E_S	$E_P(k)$–E_S	$E_P(k)$–$E_C(k)$	a

The general expressions for the H_2 formation efficiency obtained in Cazaux & Tielens (2002, Equation (9)) and Cazaux & Tielens (2004, Equation (19)) remain valid. However, the expression for $\alpha_{\rm pc}$ is calculated from the transmission coefficients that were previously underestimated. Therefore, the corrected expression for $\alpha_{\rm pc}$ is

$$\alpha_{\rm pc} = 8\sqrt{\pi T}\, \nu_{H_P} \frac{\sqrt{E_{H_C} - E_{H_P}}}{E_{H_C} - E_S} \exp\left(-2a \frac{\sqrt{2 m_H k_B (E_{H_P} - E_S)}}{\hbar} \right) + 4\nu_{H_P} \sqrt{\frac{E_{H_P} - E_S}{E_{H_C} - E_S}} \exp\left(\frac{-(E_{H_P} - E_S)}{T} \right), \tag{3}$$

where the first term is the mobility through tunneling and the second term through thermal hopping. In the original paper, the tunneling term was not taken into account because tunneling was only important at low dust temperatures and, for those conditions, direct recombination of physisorbed atoms dominates H_2 formation. With the corrected expression, this term has to be taken into account.

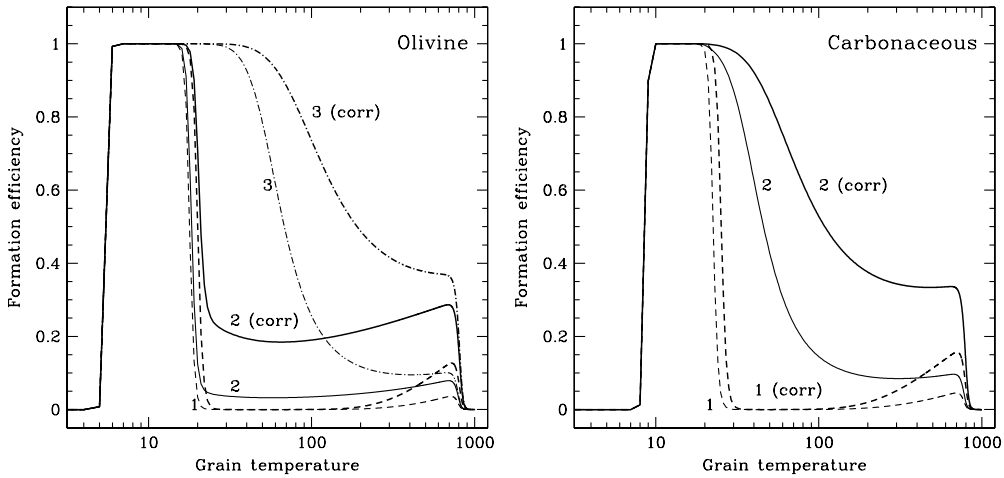

Figure 1. Efficiencies of H_2 formation as calculated in the original paper (thin lines) and corrected from the factor (think lines, also marked as corr). Each line represents a different barrier from a physisorbed site to a chemisorbed site (see Figure 15 in Cazaux & Tielens 2004).

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